A Review of Nonlinear Low Frequency (LF) Wave Observations in Space Plasmas: On the Development of Plasma Turbulence

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One of the most fundamental topics in space plasma physics is the property of nonlinear waves and their evolution to partial and full turbulence. Of the various wave phenomena in space plasmas, the cometary case is unique because there is a well-define narrow-band "pump" frequency which is essentially at the local ion cyclotron frequency in the instrument (spacecraft) rest frame. At frequencies higher than the "pump", the wave power falls-off with power-law dependences between $f^{-5/3}$ to $f^{-2.0}$, indicative of spectra developing towards Kolmogorov or Kraichnan turbulence. Detailed investigation of waves at higher and lower frequencies than the pump frequency can be used to identify daughter and granddaughter waves, and thus the mechanism(s) for the formation of plasma turbulence. Various mechanisms such as modulational and decay instabilities, four-wave processes, wave-particle interactions, dispersion and damping, all can affect and be part of these turbulent spectra. To begin the review, we will first discuss current progress in observations of nonlinear wave evolution for all three cometary cases: Grigg-Skjellerup, Giacobini-Zinner and Halley. Secondly, we will examine nonlinear waves for satellite foreshock passes which occur at distances well downstream of the Earth. Waves in this region have had greater time to evolve, allowing greater possibility of wave-wave interactions to occur and full turbulence to develop.

1. 1995
   Cambridge/Symposium
   Workshop on the Physics of Space Plasmas

2. Oral (invited)

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